OCTOBER, 1938 BULLETIN 279

AGRICULTURAL EXPERIMENT STATION

KANSAS STATE COLLEGE OF AGRICULTURE
AND APPLIED SCIENCE

MANHATTAN, KANSAS

L. E. Melchers

Smuts of Cereal and Forage Crops in Kansas and Their Control

PRINTED BY KANSAS STATE PRINTING PLANT
W. C. AUSTIN, STATE PRINTER
TOPEKA 1938
17-5658

KANSAS AGRICULTURAL EXPERIMENT STATION

MANHATTAN, KANSAS

STATE BOARD OF REGENTS

RALPH T. O'NEIL, *Chairman*, Topeka

LESTER MCCOY.....Garden City	HOWARD PAYNE .....Olathe
E. F. BECKNER.....Colby	L. J. BEYER .....Lyons
DR. H. L. SNYDER.....Winfield	LESLIE WALLACE .....Larned
C. G. NEVINS.....Dodge City	M. L. BREIDENTHAL.....Kansas City

J. A. MERMIS, *Business Manager*, Topeka

ADMINISTRATION

F. D. FARRELL.....President of the College
L. E. CALL.....Director of the Station

STAFF MEMBERS IN CHARGE

W. E. GRIMES.....Agricultural Economics
F. C. FENTON.....Agricultural Engineering
R. I. THROCKMORTON.....Agronomy
C. W. MCCAMPBELL.....Animal Husbandry
L. D. BUSHNELL.....Bacteriology
L. E. MELCHERS.....Botany
H. H. KING.....Chemistry
F. W. ATKESON.....Dairy Husbandry
G. A. DEAN.....Entomology
MARGARET M. JUSTIN.....Home Economics
W. F. PICKETT.....Horticulture
C. O. SWANSON.....Milling Industry
L. F. PAYNE.....Poultry Husbandry
R. R. DYKSTRA.....Veterinary Medicine
R. K. NABOURS.....Zoölogy

SUPERINTENDENTS OF BRANCH STATIONS

E. H. COLES.....Colby	L. M. SLOAN.....Garden City
L. C. AICHER.....Fort Hays	T. B. STINSON.....Tribune
(P. O.—Hays)	

SUMMARY—CEREAL AND FORAGE CROP SMUTS

Name of Disease.	Group.	Occurrence and location of the organism causing the disease.	Control measures.
Corn smut	1	Spores in the soil from smutted refuse	No practical method of control. Seed treatment of no use. Do not plant corn on the same land more often than once in 4 years. (Pp. 8, 10.)
Head smut of sorghum	1	Spores in the soil	Seed treatment does not control the disease. Remove and burn diseased plants. Rotate crops. Plant resistant varieties. (Pp. 8, 15.)
Flag smut of wheat	1	Spores in the soil and on seed	Rotate crops. Treat seed. Grow resistant varieties. (Pp. 22, 36.)
Kernel smut of sorghum	2	Spores lodged on the outside of the seed	(1) Chemical dust treatment. (Page 36.) (2) Formaldehyde treatment: 1 pint to 30 gallons of water; soak for ½ hour. (Page 36.)
Smut of oats	2	Infection lodged on or between the glumes of the seed	(1) Chemical dust treatment. (Page 37.) (2) Formaldehyde treatment: 1 pint to 10 gallons of water; sprinkle seed and allow to stand for 5 hours or over night. (Page 37.) Formaldehyde spray method may be used in place of the sprinkling method. (Page 37.)
Stinking smut of wheat	2	Spores lodged on the outside of the seed	Chemical dust treatments, copper carbonate, New Improved Ceresan, etc. (Page 36.)
Kernel smut of millet	2	Spores lodged on the outside of the seed	(1) Chemical dust treatment. (Page 37.) (2) Formaldehyde treatment: 1 pint to 45 gallons of water, soaking the seed for two hours. Use the dipping method. (Page 37.)
Covered smut of barley	2	Infection lodged on or between the glumes of the seed	(1) Chemical dust treatment. (Page 37.) (2) Soak 2 hours in a solution, 1 pint formaldehyde to 40 gallons of water. Use seed that has been cleaned. (Page 37.)
Loose smut of wheat	3	The infection *inside* the seed itself	Modified hot-water treatment. Maintain a seed plot. (Page 35.)
Loose smut of barley	3	The infection *inside* the seed itself	Modified hot-water treatment. Maintain a seed plot. (Page 35.)

TABLE OF CONTENTS

SMUTS OF CEREAL AND FORAGE CROPS IN KANSAS AND THEIR CONTROL[1]

L. E. Melchers

LOSSES FROM SMUT DISEASES

The smuts of wheat, oats, barley, corn, sorghum, and millet are known to most farmers, since these diseases occur in all parts of Kansas wherever one of these crops is grown. They are widespread and destructive. Millions of bushels of grain are lost annually from these diseases. Most of this loss, however, can be prevented by applying remedial measures at little cost.

The approximate loss from smut in a field is not difficult to estimate. Generally speaking, a smutted plant does not produce seed or grain, except in the case of corn. The percentage of smut may be determined by counting the number of smutted and healthy plants in a given area. Generally speaking, the percentage loss in yield is somewhat lower than the percentage of smut. The value of the crop varies from year to year; therefore, the loss in bushels or dollars may be roughly estimated by calculating what the yield or value of the crop would have been if the smut had not been present.

Generally, it is not realized that farmers in Kansas probably lose as much from the grain smut diseases as from diseases of livestock. It is impossible to give accurate figures on annual loss in dollars from livestock diseases, and it is therefore unsatisfactory to attempt to make a direct comparison between plant and animal disease losses in Kansas.

The losses from plant diseases vary from year to year just as in the case of livestock. Using the period 1931, 1932 and 1933, the losses from three plant diseases alone, in Kansas, namely, the smut diseases of wheat, oats, and sorghum, are conservatively estimated as follows:

	1931	1932	1933
Wheat stinking smut (bunt)	$8,116,350	$3,922,050	$1,305,690
Sorghum smut	140,117	138,732	189,308
Oat smut	771,970	513,920	595,980
Totals	$9,028,437	$4,574,702	$2,090,978

The losses from the other plant diseases attacking these crops, as the stem rust, leaf rust, foot-rot diseases, etc., are not included here; if they were, the figures would be greatly increased. There are certain years when outbreaks of plant diseases occur, such as 1926, when the loss from the stinking smut of wheat in Kansas alone was over $14,811,000. In 1936 the loss from oat smut in Kansas amounted to 20 percent of the entire crop, which was a loss of 8,046,500 bushels. At the minimum price, the money loss was

1. Contribution No. 362 from the Department of Botany.

$3,621,000. Although farmers are more impressed by the loss of livestock from disease than by the loss from plant diseases, the latter is important and can be greatly reduced by simple treatments.

The loss from the bunt, or stinking smut of wheat, varies greatly. Fields in Kansas have been observed to have as high as 85 percent smut. The loose smut of wheat, although not so abundant in Kansas, is by no means uncommon. It has been on the increase for the last 12 years. Nearly every field has 1 percent or less and frequently fields are encountered that have from 5 to 15 percent loose smut.

Flag smut of wheat was first found in northeastern Kansas in 1923 and has been confined to two or three counties which grow mostly soft or semihard varieties. The loss is not large, but occasional fields are rather heavily smutted. Fortunately, this smut has not spread to new areas in Kansas and studies have shown that the hard winter varieties are resistant.

Oat smut is always present in Kansas when fields are planted with untreated seed. Fields planted with untreated seed may have as high as 40 percent smut. In 1936 there occurred the most destructive outbreak of oat smut in the history of Kansas agriculture. Occasional fields had as high as 95 percent loss from smut, and many others were too smutty to be harvested for grain. Where seed disinfection is carefully practiced according to recommendations, the loss from oat smut is negligible.

Barley smuts are always present. In certain varieties, such as Flynn, the loose smut has become a serious problem. Like the loose smut of wheat, the matter of control is not easy because a special hot-water treatment is required. Many barley fields have from 1 to 4 percent loose smut and occasionally fields are found to contain 10 to 50 percent. The covered smut of barley is found in most fields planted with untreated seed, and as a rule, 1 to 5 percent occur in spring barley. In 1936 this smut was unusually common and heavy losses occurred in many fields of winter barley. Winter and spring barley varieties are subject to the same smut diseases.

Covered smut of barley seems to be increasing rapidly and is especially prevalent and destructive in winter barley in south central Kansas.

Millet, although not extensively grown in Kansas, has a smut disease that at times becomes troublesome. Farmers have reported from 1 to 25 percent of their millet crop destroyed by smut.

There are two smut diseases attacking the sorghum crop in Kansas, the covered kernel smut and the head smut. Fields are found each year that contain from a trace to 75 percent kernel smut. The kernel smut, which is the most common and destructive, is a disease which can be completely and easily controlled by seed treatment.

The less common head smut is only occasionally found and then usually in varieties of sorgo such as Red Amber, Freed, and Sumac. This disease is neither widespread nor destructive in its attack on the sorghum crop of Kansas. It does not seem likely that head smut

will become a troublesome disease in Kansas, as it has been known to occur in the state for 50 years and does not appear to be on the increase.

Broomcorn is affected by both of these smuts to some degree. The greatest damage to this crop is from the kernel smut, which has the singular effect of not only destroying the seed, but the fungus also injures the brush, discoloring it and causing a central, thickened stem to appear in the heads. This produces a brush of inferior quality. It is not uncommon to find from 5 to 10 percent of the broomcorn plants attacked.

Corn smut is found abundantly in every cornfield in Kansas. In fact, it occurs wherever maize is grown in the United States. It is common and destructive to all varieties of sweet corn. The actual loss in a field cannot be determined with any degree of accuracy. Since the smut may attack various parts of a plant other than the ear, the actual amount of injury may be only approximated. It is believed, however, that a badly smutted plant has its yielding capacity reduced by one third.

From 5 to 80 percent of the plants in a field may show smut. As in the case of the other smut diseases, corn smut is worse some years than others. It is safe to say that several million bushels of corn are lost each year in Kansas from corn smut.

There is a smut disease attacking rye, but this crop is not extensively grown in Kansas and the smut has only rarely been observed.

CAUSE OF THE SMUT DISEASES

Smut diseases are caused by minute parasitic plants known as fungi and not by hot, muggy weather, "sour sap," or the time at which the crop is planted, as sometimes believed. As a rule these fungi infect either by entering the young floral parts, or by gaining entrance to the plant in the seedling stage and developing within the tissues of their hosts. As long as the fungus remains within the tissues there is nothing externally visible by which its presence can be detected; hence, it is not easy to determine from outside appearances whether a plant in its early stage of development is infected. When the fruiting stage is reached, the diseased plants can be readily detected. As the infected plants mature and begin to form seed, the diseased parts are transformed into a more or less black, powdery dust. This is characteristic of the smut fungi. The black dust is composed of an infinite number of microscopic, reproductive bodies of the fungus, known as "spores." These perpetuate and propagate the disease from year to year, either by clinging to the outside of the seed and hulls when a crop is threshed, or by infecting the interior of the developing seed (germ) during the flowering period, or by infecting the regions of the glumes.

The various smut diseases of plants are caused by different kinds or species of smuts. They affect the cereals and other plants in various ways, but each different smut disease is produced by a specific fungus. For example, the spores of the stinking smut of

wheat cannot produce the loose smut of wheat, the smuts of barley, or corn smut. A given smut fungus will cause only its own specific disease. Wheat seed might be contaminated with oat smut spores and planted, but the oat smut disease would not result on the wheat plant, nor would wheat smut result from this contamination. For the same reason, if a badly smutted crop of oats is grown in a certain field, there is no danger in planting a wheat crop on the field the following year, as wheat smut would not result from such a practice.

It should be noted that a number of Kansas crops which are quite distinct from the farmer's point of view are botanically closely related. These comprise the general group known as the sorghums, and include kafir, feterita, broomcorn, milo, Sudan grass, and sorgos (cane). The kinds of smut attacking kafir, therefore, also occur on all the other susceptible sorghums. As a rule, milo and feterita are highly resistant to the smut diseases.

THREE GROUPS OF SMUT

Since there are 11 important cereal and forage crop smut diseases in Kansas, it seems desirable to group them according to their life habits, so as to simplify what is known regarding their mode of living and the knowledge pertaining to their control. Smut diseases of cereals may be placed in one of three groups, based on their life cycle. (See summary.) These groups, with the smuts included therein, may be described as follows:

Group 1.—Corn Smut, Head Smut of the Sorghums, and Flag Smut of Wheat

The smuts of this group cannot be prevented by treating the seed. The organisms which cause and perpetuate these diseases are not necessarily carried on the outside of the seed. Corn smut, the head smut of sorghum, and the flag smut of wheat belong in this group.

Infection results chiefly from the spores which live and winter over in the soil or in manure which has become contaminated with smut spores. There is, however, some difference between the life habits of corn smut, head smut of sorghum, and flag smut of wheat. As far as is known, in the case of the corn smut, most of the infection appears to be due to secondary spores resulting from the germination of the overwintered spores in the soil. These are carried by the wind from the soil and alight on the young corn plants, causing local infection. Later a smut boil may develop wherever infection has occurred. The infection may be on the ear, tassel, leaf sheath, or node; in other words, a local infection.

In the case of the head smut of sorghum and the flag smut of wheat, the fungus gets into the seedling directly from the soil, and in that way alone causes infection. This is called a systemic infection. The spores which infect are not carried to the aerial parts of the plant, as in corn smut. Once inside the sorghum seedling, or wheat plant, the fungus grows within the tissues and keeps pace with their development. In sorghum no evidence of disease is seen until

the head emerges from the sheath, when instead of a head of grain a smutted mass results. In the case of the flag smut of wheat, the spore masses occur in long linear stripes or streaks in the leaf and leaf sheath when the plant is about half grown.

The spores producing all three of these diseases live over in the soil. It is always advisable, however, to disinfect the surfaces of sorghum and wheat seed so as to kill spores of smuts that may be present.

Group 2.—Kernel Smut of the Sorghums, Stinking Smut of Wheat, Smut of Oats, Covered Smut of Barley, and Smut of Millet

The smuts of this group have been thoroughly studied, and it has been found that they can be controlled by seed treatments, since the spores of the fungi causing these diseases cling to the seed. The kernel smut of the sorghums, the stinking smut of wheat (bunt), the smuts of oats, the covered smut of barley, and the smut of millet all belong in this group.

The smut spores are scattered at harvest time, chiefly in threshing, by the wind, and are further disseminated by means of contaminated machinery, sacks, or bins. If smutted seed is planted, the adhering smut spores germinate simultaneously with the sprouting seed. The fungus penetrates the tissues of the seedling, keeping pace with its growth until heading time approaches. Instead of producing a normal kernel, a mass of smut or "smut balls" occurs in place of each kernel. The spores comprising these masses are scattered by various agencies, and cling to the outside of healthy seed. When this seed is planted, the same series of events is repeated.

In Kansas, the spores causing these different smut diseases do not live over in the soil. This group of smuts is, therefore, controlled by disinfecting the surface of the seed before planting.

Group 3.—The Loose Smuts of Wheat and Barley

There are two smuts in this group, namely, the loose smuts of wheat and barley. They may be prevented by treating the seed, but only by a special kind of hot-water treatment. The infection producing these diseases is found between the glumes and inside the seed; that is, **infection exists inside the "germ" or embryo of the seed and in the hulls of the barley.**

When the heads emerge from the "boot" in wheat and barley, one may notice the first indications of loose smut. In place of seed formation, a loose, powdery mass of spores develops. All or most of the glumes and beards are absent, and the smut mass clings to the stem (rachis). These spore masses are soon scattered, leaving the naked stems (rachises) of the heads remaining. The spores are carried to neighboring healthy plants, which are in full bloom. If they alight on the ovary of the flower of wheat or barley at just the right stage, they germinate, penetrate it, and infect the "germ" of the growing seed. Infection also takes place in the glumes of barley. After infection has resulted, the fungus goes into a resting

stage and remains quiescent. The seed, however, continues to grow, and develops into a normal appearing kernel although it is **internally** infected with the loose smut fungus. If this seed is planted the next year without special treatment, the plant developing therefrom will be affected with the loose smut, for the fungus is **inside** the "germ" of the seed, and will grow inside the developing plant until it reaches maturity.

A table giving the common names and control measures for the various smuts occurring in Kansas is found in the summary.

CHARACTERISTICS OF THE DIFFERENT SMUTS

Corn Smut

Corn smut, *Ustilago zeae* (Beck.) Ung., is usually found on the tassel, ear, lower ear buds, or at the nodes of the plant (fig. 1). Occasionally it will also be found on the stalk and leaves. This disease attacks field corn, popcorn, and sweet corn and is a real pest. In the early stages, the smut masses are white and covered with a thin, grey membrane, which at certain stages has a silvery luster. (Fig. 1, A and D.) As the smut mass matures, it becomes black internally, and the surrounding membrane ruptures, releasing the black spores. These "smut boils" contain millions of spores which are scattered by the wind and rain. They fall to the soil and also are distributed over the corn fodder, which is fed to livestock. The spores withstand extremes of weather conditions, such as freezing and drying. The spores may live over for several years in the soil.

It has been found that the spores lose their infective power, however, after passing through the alimentary canal of animals.

There is no satisfactory method of control for corn smut. If land is not planted to corn more often than once in every fourth year, the loss from smut appears to be less. No varieties are resistant and, generally speaking, all are equally susceptible. The time of planting has no marked effect on the amount of corn smut that is obtained. It is hoped that some day, by the production of hybrid corn, varieties or hybrids will be obtained that show some resistance. At the present time there are no such varieties available for Kansas.

Smuts of Sorghum

Up to 1891 the sorghum smuts were uncommon in Kansas, but since then they have been increasing steadily. Those who have grown kafir, cane, Sudan grass, or broomcorn undoubtedly have seen sorghum smut.

There are two principal species or kinds of sorghum smut found in this state, namely, the head smut (fig. 2) and the kernel smut (fig. 3). The latter is the more common and destructive in Kansas.

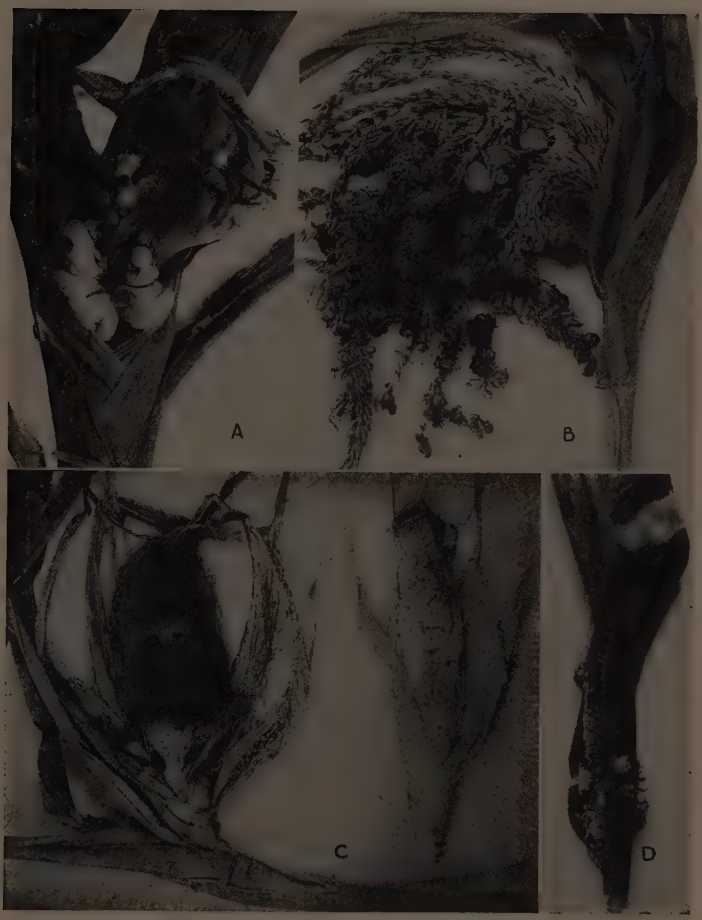


FIG. 1.—Corn smut on various parts of the plant.

As a rule milo and feterita are resistant to both the sorghum smuts, but in recent years certain physiologic races of kernel smut have been known to attack these varieties to a slight extent. Since sorghums show a difference in degree of susceptibility to kernel smut.

FIG. 2.—Head smut of sorghum.

it is hoped by breeding to produce a resistant variety that has good yielding qualities. Kafirs are especially susceptible to sorghum kernel smut, as are also the sorgos.

Kernel smuts, *Sphacelotheca sorghi* (Lk.) Cl., and *Sphacelotheca cruenta* (Kühn) Potter,[2] are noticeable when the sorghums begin to

2. This is the loose kernel smut of sorghum, shown to be botanically different from the ordinary kernel smut. It is not commonly found in Kansas. For the purpose of this bulletin, therefore, they may be treated under one head.

FIG. 3.—Kernel smut of sorghum. (A) Normal head of kafir. (B) A head attacked by the kernel smut.

head. Close examination shows that affected heads bear "false" kernels. These are composed of a mass of smut spores enclosed in a conelike, grayishbrown, slightly toughened membrane. (Fig. 4, A.) This breaks very readily in threshing, thereby liberating the enclosed spore masses. If one of the "false" kernels is crushed between the fingers the black smut "dust" contained therein will be observed. The kernels are the only part of the head which is transformed into these masses of smut spores. This sorghum smut perpetuates itself from year to year by means of the spores which adhere to the

FIG. 4.—Kernel smut of sorghum showing false kernels and normal kernels. (A) False conical shaped bodies containing smut spores. (B) Normal kernels of kafir.

normal sorghum seed. If such contaminated seed is planted without killing the adhering smut spores, the crop therefrom will be diseased with the kernel smut.

The method of control is either by the use of copper carbonate, New Improved Ceresan, or the formaldehyde treatment. It would pay to collect the seed from smut-free plants while the plants are still standing in the field. Not only does this enable the grower to select clean seed, but it also gives him the opportunity to select typical heads of sorghum. Such seed could be threshed by itself, thereby reducing the chance for contamination.

Head smut of sorghum, *Sorosporium reilianum* McAlp., is very different in appearance from the kernel smut of sorghum, in that the

entire head is usually destroyed. The glumes and branches of the head, as well as the grain, are transformed into a sooty black mass of spores (fig. 2). This condition is noticed as soon as the diseased head emerges from the "boot" of the plant. The black mass is covered with, a very thin, whitish membrane which soon ruptures, disappears and allows the spore mass to be dispersed by the wind and rain. The spores may remain alive in the soil until the following year. If especially susceptible varieties of sorghums, such as Red Amber, Freed, and Sumac, are grown on contaminated land, infection occurs in the young seedlings, and later, smutted plants appear.

FIG. 5.—Normal, partially smutted, and smutted panicles of oats.

Rotation of crops, the planting of varieties of sorghum that have been observed to be free of head smut, and the prompt removal and burning of smutted heads, will control this disease under Kansas conditions.

Smuts of Oats

Oat smut, *Ustilago avenae* (Pers.) Jens., and *Ustilago levis* (Kell. and Sw.) Magn., as found in Kansas, is recognized by the black masses of spores which replace the normal grain. While these two smuts are different species and are slightly different in appearance in the field, they will be treated as one in this discussion since the treatment is identical in each case. The former, *U. avenae,* is known

as the loose smut, and *U. levis* is known as the covered smut. Oat smut is first noticed as the panicles emerge from the "boots" of the plants (fig. 5). The grain, and sometimes the chaff, is replaced by this dusty mass, which may later be dispersed, leaving a more or less naked panicle. Generally all the heads of an affected plant are smutted. Diseased plants are often shorter and stand more erect than normal plants. The diseased plants often escape notice, but they may be recognized in the field, even before the panicles emerge from the "boot," by the fact that the uppermost leaf of the diseased plant assumes a yellowish or reddish-yellow color.

Certain chemical dust treatments or the use of formaldehyde are the methods of control. (Page 37.)

Smuts of Wheat

The stinking smut of wheat, *Tilletia foetens* (B. & C.) Trel. and *T. tritici* (Bjerk.) Wint., is commonly called covered smut, closed smut, bunt, or stinking smut. The two organisms causing the disease are closely related species. In Kansas *T. foetens* is essentially the only one present, while in the northwestern part of the United States, *T. tritici* is commonly found. In Oregon and Washington the bunt organism lives over in the soil, but in Kansas little difficulty has occurred in this respect. Seed treatment, therefore, under Kansas conditions is a reliable method of control.

The spore masses are enclosed in a more or less brittle, grayish-brown membrane, enlarged or swollen, and commonly called a "smut ball" (fig. 6). By comparing them with healthy kernels, one finds that they are more spherical, lighter weight, and if viewed externally are generally brownish in color, with roughened or pitted surfaces. These smut masses are not scattered about by the wind, but are held within the membrane. If this is broken in threshing, however, the spores are scattered, and lodge in the brush and crease of the clean seed, thereby contaminating it.

When the wheat plant begins to head, the disease cannot be recognized by casual examination of the spike or head of wheat alone. In general, a bunted head resembles a normal one (fig. 7). However, diseased heads are darker green when young, and when mature, almost always shorter and somewhat darker in color, with the chaff spreading. Generally all the kernels in a head are attacked, and all the heads in a plant are diseased. Such heads have a foetid odor, not unlike decayed fish; hence the common name, "stinking smut."

The loss from bunt not only results from the damage to the grain itself, but the foetid odor of the smut is such that a small quantity mixed with grain is sufficient to materially reduce the grade of the wheat, and consequently its market value. Smutted grain cannot be used for flour making unless a special scouring process is used to wash the wheat free of smut.

In some parts of the country serious explosions have occurred in separators and elevators, due to the presence of this smut dust during the threshing and handling of badly smutted crops. Workmen

FIG. 6.—(A) Normal kernels of wheat. (B) Smut balls. (C) Smut ball cut in two, showing black mass of smut spores. (D) Wheat kernels in which the "brush" or tip of kernel is covered with smut spores. (E) A wheat spikelet dissected, showing the smut balls hidden within the glumes like a wheat kernel.

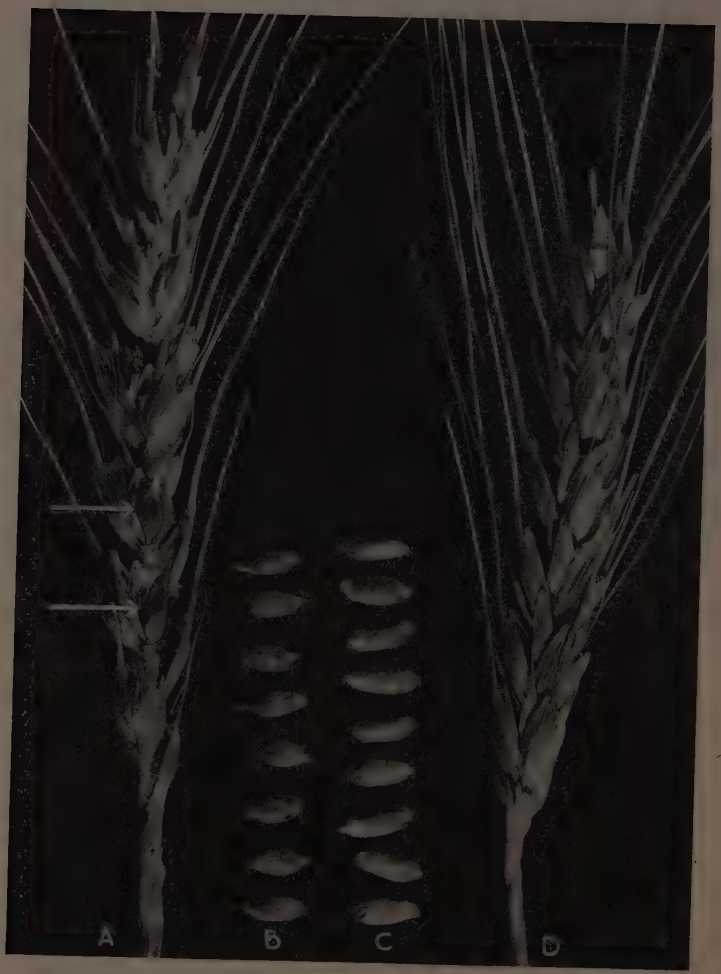


FIG. 7.—Bunt or stinking smut of wheat. (A) Smutted wheat head; arrows show smut balls hidden within the glumes. (B) Smut balls. (C) Normal kernels of wheat. (D) Normal head of wheat. From general outward appearance it cannot be distinguished from the smutted head.

are frequently annoyed by breathing the "black smoke" resulting from threshing a smutted crop.

This disease is controlled by one of the chemical dust treatments. (Page 36.)

The loose smut of wheat, *Ustilago tritici* (Pers.) Jens., is first apparent as the heading stage approaches. It is quite different from the stinking smut in that all the glumes or chaff, as well as the kernels, are transformed by the smut fungus into a loose, dusty,

FIG. 8.—Loose smut of wheat. Note that the glumes are entirely destroyed by loose smut, which is not the case in bunt.

black mass of spores (fig. 8). These masses do not adhere very long to the wheat plant, but are blown away or removed by the rain, leaving only naked wheat stems (rachises). The heads are completely destroyed, and the smut usually attacks every head in a plant. Although this disease is not so abundant in the hard varieties of wheat in Kansas as the stinking smut, it is by no means uncommon, is widely distributed, and is apparently on the increase in some varieties. As a rule the hard winter wheat varieties grown in Kansas are not very susceptible.

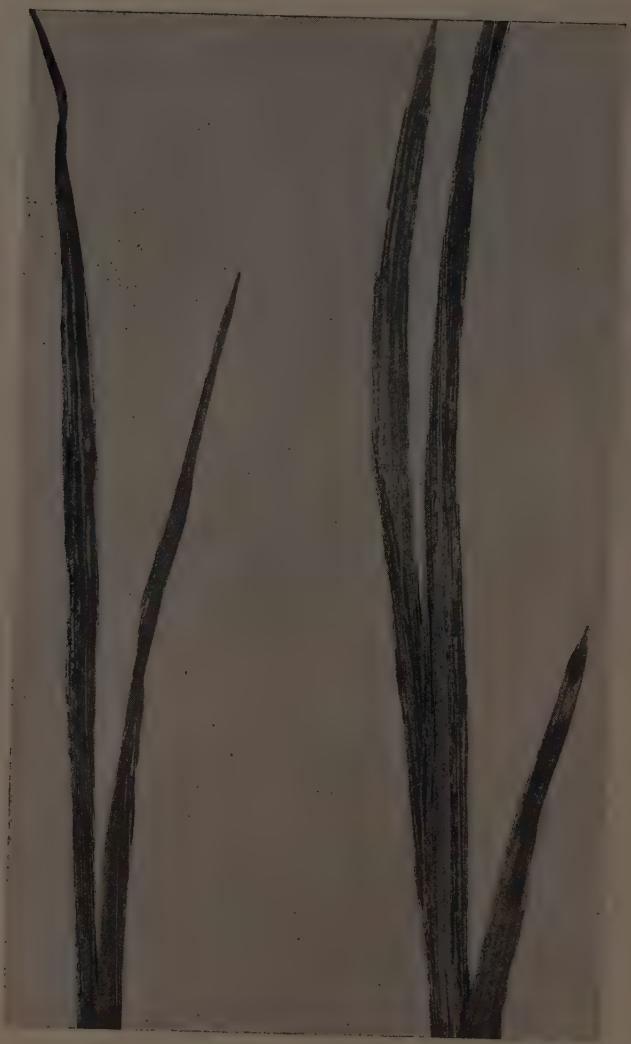


FIG. 9.—Flag or stripe smut of wheat. The leaves have long, black or grey stripes which are conspicuous when the plants approach the heading stage.

FIG. 10.—Covered smut of barley. (A) Left, normal head. Right, two smutted heads. The beards are not destroyed and the smut masses are held together by a membrane. (B) A sample of smutted barley. Covered smut of barley breaks up in lumps. (See next page.)

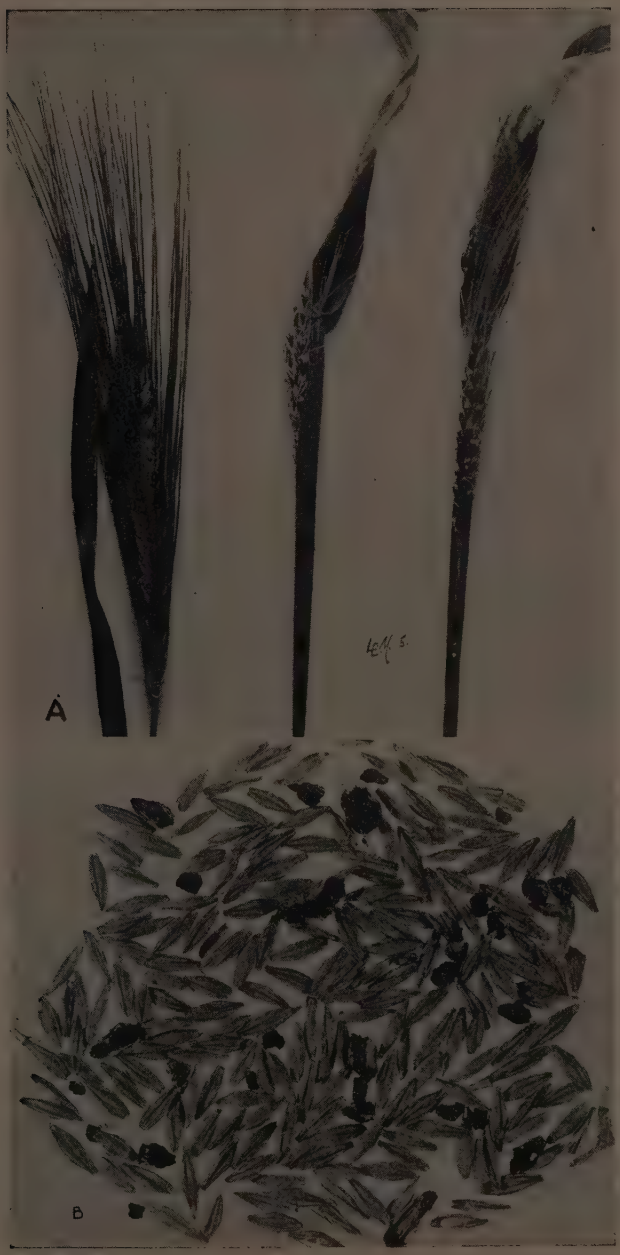


Fig. 10.

The treatment for this disease is a special method, known as the modified hot-water treatment. (Page 35.) It is difficult to carry out because the temperature of the water must be very carefully regulated. The modified hot-water treatment ordinarily cannot be used on a large scale. Small quantities of seed wheat may be treated with this method and this seed used for increase purposes. Even then, very few wheat growers are equipped to use the method satisfactorily.

Flag smut of wheat, *Urocystis tritici* Koern., was first found in northeastern Kansas in 1923. Flag smut has been confined chiefly to Leavenworth and Wyandotte counties, where it occurs mainly on Harvest Queen, although it is found on some other local varieties. This disease has not become a serious factor in wheat production in northeastern Kansas. Experiments have been conducted with numerous wheat varieties, and it has been found that standard hard, winter wheats are resistant to flag smut. Apparently there is little danger that this disease will become a problem in the main hard wheat belt of Kansas. Such varieties as Kawvale, Tenmarq, and Clarkan are highly resistant, and it is recommended that one of these be grown where flag smut becomes troublesome in northeastern Kansas.

The disease is easily recognized by the long, linear, narrow stripes of grey or black ruptures on the leaves. (Fig. 9.) Diseased plants are stunted and generally do not produce heads. The spores fall to the soil or carry over on the threshed seed and when the seed is sown without treatment, the young plants become infected. Seed treatment in itself, however, does not control flag smut, because the organism may live over in the soil from year to year. Care should be exercised to avoid establishing flag smut in soils that are free of it.

Smut of Millet

Millet smut, *Ustilago crameri* Körn., frequently becomes troublesome in millet-growing communities. It is a "kernel smut," the smut masses being enclosed in a membrane and replacing each kernel separately. When this membrane is broken in threshing, the spores are scattered and cling to the seed.

German millet seed is more frequently contaminated with this smut than other varieties. It is, therefore, better to secure seed in a region where smut does not occur. Where there is the possibility of seed contamination, treatment is advisable. The copper carbonate, New Improved Ceresan, and formaldehyde methods are means of control. (Page 37.)

Smuts of Barley

In the covered smut of barley, *Ustilago hordei* (Pers.) K. & S., the smut masses replace part of the chaff and the entire grain. A greyish membrane covers the smut mass (fig. 10, A). This is rather thin and transparent, and shows the greenish-black spore mass contained therein. The spores are not scattered about by the wind and rain,

unless the membrane is broken, which does not usually occur until threshing. The spore masses break up in lumps and the mass is not so powdery as in other smuts. (Fig. 10, B.)

The New Improved Ceresan and the formaldehyde treatments are the means of control. (Page 37.)

The loose smuts of barley, *Ustilago nuda* (Jens.) K. & S. and *Ustilago nigra* Tapke, like the loose smut of wheat, are most noticeable as the heads emerge from the "boot." The loose smut of barley is less abundant in Kansas than the covered smut and is the more

FIG. 11.—Loose smut of barley. (A) Normal head of barley. (B) Four heads showing loose smut in various stages of development. The smut masses are easily dispersed by wind and rain.

difficult to control. The loose smuts of barley and wheat resemble each other, not only in their appearance, but also to some extent, at least, in their life habits and their manner of infection. There are really two species of loose barley smut, but for the purpose of this discussion they will be treated as one. The chaff and kernels are replaced by a dark, sooty mass of spores, which, viewed in a mass, are black in color and adhere loosely to the stem (rachis) of the head. The smut mass is not enclosed in an enveloping membrane except in the early stages, and this soon ruptures (fig. 11). On account of this fact, the spore masses are dispersed by the wind and washed away by rain. Before harvesting time arrives, smutted heads become bare stems (rachises), thus furnishing an indication that the loose smut of barley is present.

The modified hot-water treatment is the only satisfactory method of control, and the objectionable features of this method already have been mentioned. (Pages 22 and 35.)

ARE CEREAL AND FORAGE-CROP SMUTS POISONOUS TO LIVESTOCK?

People frequently write to the Kansas Agricultural Experiment Station to learn whether the feeding of smutty corn, sorghum, barley, oat hay, etc., is injurious or dangerous to livestock. Members of the Department of Botany of the Kansas Agricultural Experiment Station have conducted experiments to discover what effect the feeding of large quantities of corn smut and sorghum (kafir and cane) smut have on horses, cows, and calves. The tests showed conclusively that these smuts are in no way dangerous or poisonous to such animals. In fact, in the experiments conducted, some animals gained weight over a period of time. The only disturbance noted was coughing or sneezing at times because of the smut spores which make a dusty mass. It should be emphasized that the quantities of smut fed to the animals in these tests were much greater than would be eaten at one time under ordinary field or farm-lot conditions.

No evidence was obtained that feeding smutty oat hay, such as occurred so abundantly in 1936, has had any ill effects on livestock.

It should be kept in mind that mouldy hay or fodder do not come under the same heading as grain and forage-crop smuts. It is known that, under certain conditions, the feeding of mouldy hay or fodder is decidedly injurious and dangerous.

No experiments have been conducted at the Kansas Agricultural Experiment Station on the feeding of wheat or barley grain that is badly smutted. As hogs are more sensitive than other animals to mouldy feed, and as no experiments on the feeding of badly smutted wheat or barley grain to hogs have been conducted at the Kansas Agricultural Experiment Station at Manhattan, the following recent observations are of interest.

In 1935 hogs were fed wheat bunt offal at Hays, Kan. The smut came from a mill that had used smutted wheat for milling purposes. A farmer fed large quantities of the smut over an extended period of

time and his report showed that the smut offal did not injure hogs, but that it was necessary to use additional nutrients or supplements to secure desired gains in weight of animals. In this instance the hogs received much more smut than they would if fed smutted wheat, since little grain was present in the smut offal.

In 1936 limited feeding tests were made by another farmer at Ransom, Kan. He fed badly smutted barley to hogs and a calf over a period of several months. The farmer reported that no injury resulted and that all the animals grew and increased in weight in a normal manner.

Chickens will not be injured by eating smutty grain.

If in doubt, it is always wise first to try feeding one or two animals with questionable feed over a period of time and note the results.

SEED TREATMENTS TO PREVENT SMUTS

The prevention of losses from cereal smuts is a problem which confronts every farmer who is growing small grains or forage crops. The old proverb, "An ounce of prevention is better than a pound of cure," applies here, since cures of infected plants are either impracticable or impossible.

Most of the smuts can be controlled by treating the seed; therefore, the problem is largely one of prevention. Proper treatment of seed before planting is the principal means of reducing the annual losses caused by these plant diseases. It is desirable that all seed which is to be treated should be carefully cleaned by fanning. This will remove smut masses, weed seed, light-weight grain, and chaff. Unless clean seed is used the results from seed treatment will not be so satisfactory.

The most common treatments used at the present time for preventing smut are: (1) the chemical dust treatments, (2) the formaldehyde ("formalin") treatment, and (3) the modified hot-water treatment.

Chemical Dust Treatments

With the discovery that certain chemical dusts are good fungicides, seed treatments for grain smuts have become simplified. The application of a dust in place of a solution does away with the wetting and swelling of seed and other objectionable features accompanying wet treatments.

Numerous chemical "dusts" are on the market and the grower is advised to use those products which have given satisfactory control of smuts. Various brands of copper carbonate have been widely and successfully used for the control of certain cereal smuts. Copper carbonate is not recommended for oats and barley smuts; therefore, the growers should follow the specific recommendations made for the smut concerned. Certain chemical dusts contain some form of mercury, such as ethyl mercury phosphate (New Improved Ceresan, for example). These have proved to be effective for the control of certain of the cereal smuts. Some of the advantages of the dust or dry treatments over the formaldehyde wet treatment are as follows:

1. The dust treatments are easily applied and the seed does not become wet or swollen.
2. Seed may be stored for long periods.
3. The germination of treated seed is not injured if recommendations are carefully followed.
4. The cost is not excessive.
5. The control of smut is just as effective as that obtained with the wet method.
6. Treated seed can be planted in either dry or moist soil.
7. Better stands are generally obtained from treated seed than from untreated seed.

FIG. 12.—Dust treating outfits for smut control. (A) Churn used to treat small seed lots. (B) Homemade barrel treater.

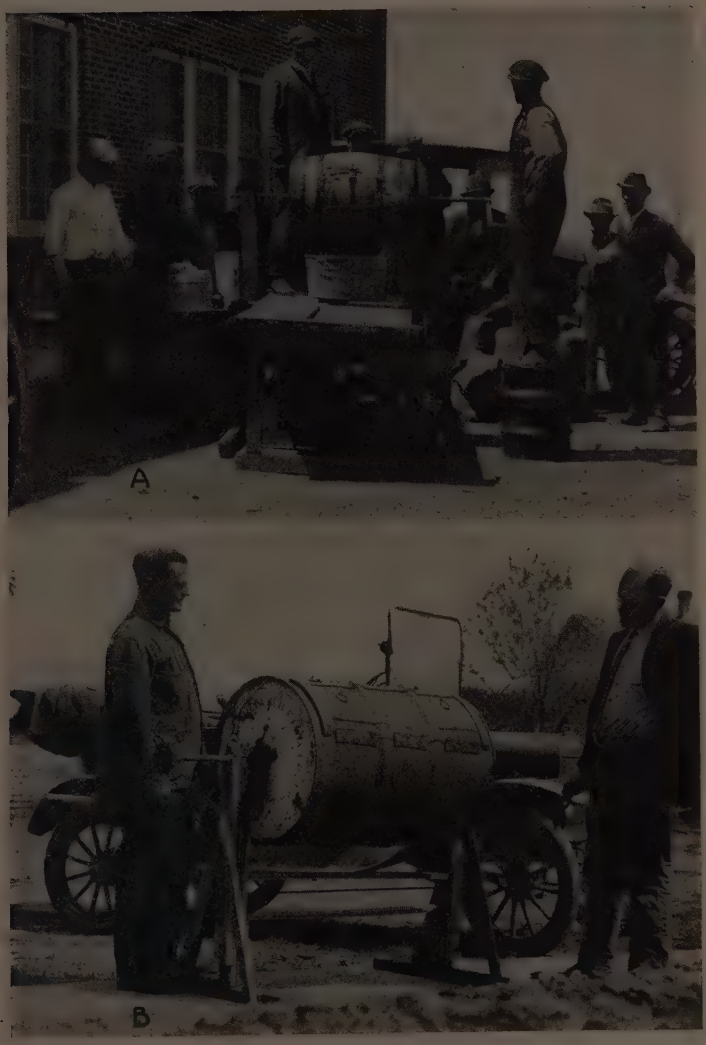


FIG. 13.—Homemade barrel treaters. (A) Wooden barrel mounted on platform. (B) Oil drum made into dust treater.

In treating seed with the chemical dusts, follow closely the directions given by the manufacturer of the product which is being used. The dust and seed must be thoroughly mixed, so the seed becomes covered with the dust. Various dust treating machines are on the market and homemade equipment is found in every community where seed wheat has been treated for smut.

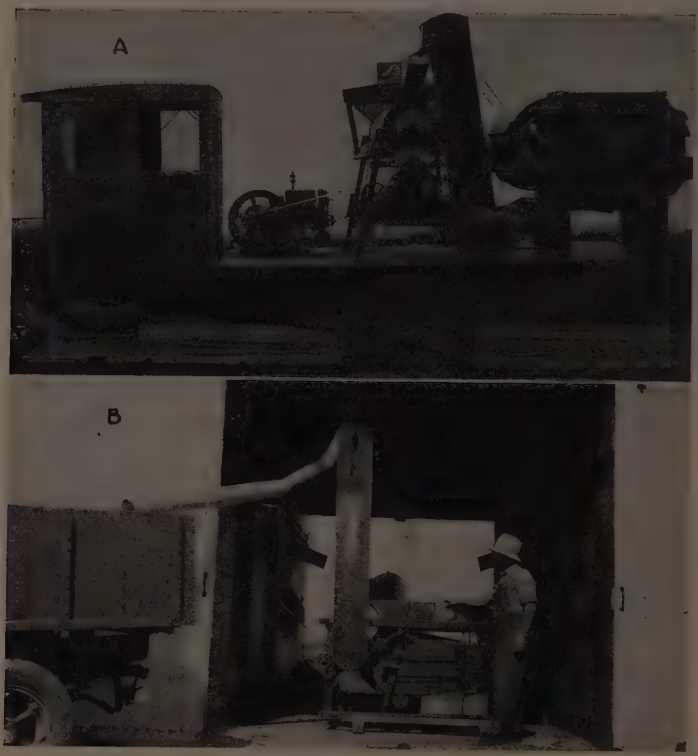


FIG. 14.—Large capacity seed cleaner and treater for copper carbonate dust treatment. (A) Portable seed cleaner and treater used for wheat bunt control. (B) Cleaner and treater in an elevator where large quantities of seed are treated with the copper carbonate.

Some of the more common types of treaters used in "dusting" the seed of wheat, oats, barley, and sorghum are illustrated in figures 12 to 16.

Churn or barrel treaters are used when small quantities of seed are treated (figs. 12 and 13).

Large capacity commercial treaters for copper carbonate are shown in figure 14. Several hundred bushels of seed may be treated in a day with these outfits.

If Coppercarb or copper carbonate is used, it is imperative that the seed and chemical dust be thoroughly mixed so that every kernel is completely covered. This can be done only when equipment is used as illustrated in figures 12, 13, and 14.

With the introduction of New Improved Ceresan, it has been found unnecessary to mix the chemical dust and seed as thoroughly as is necessary when copper carbonate is used. The principle here is to mix the dust and seed and allow the treated seed to stand in **an uncovered** pile for at least 24 hours, and 48 hours are preferred. The fumes of this chemical penetrate the entire pile and kill the spores of the smut fungus. A simple, large-capacity gravity treater for the use of New Improved Ceresan has been devised at the Illinois Agricultural Experiment Station and has been modified at the Kansas Agricultural Experiment Station. Several hundred bushels of oats, barley, wheat, or sorghum may be treated in a day. (Fig. 15.) Place the treater on a low platform or in a doorway so that seed flowing from the machine will not pile up in front of mouth opening.

Precautions as to masks and ventilation should be followed.

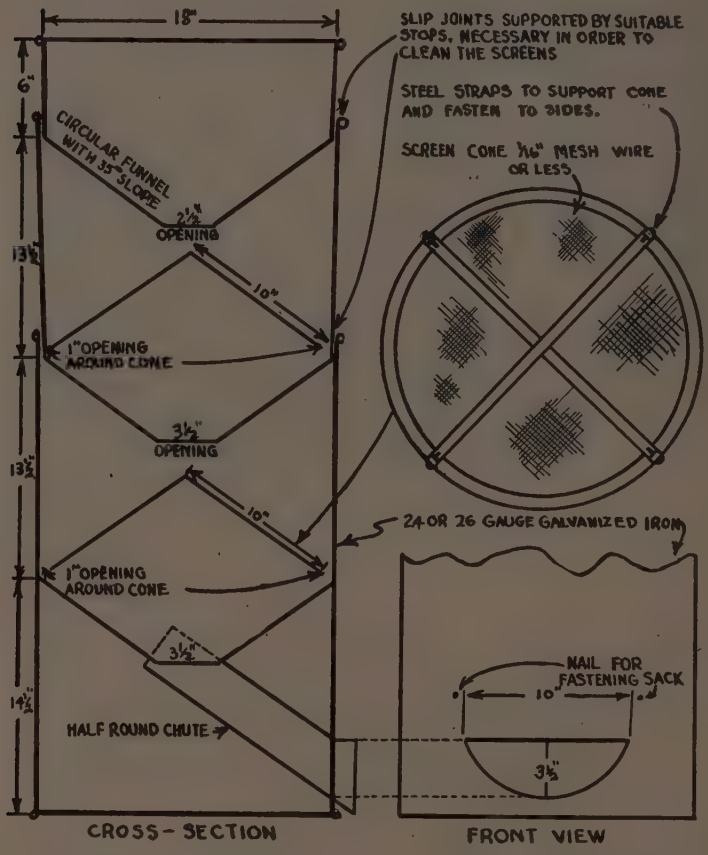
Do not allow New Improved Ceresan to accumulate on the skin; wash exposed portions of the body with soap and water.

To begin treating, first stop the opening in the upper funnel by placing over it a small piece of cloth or canvas, with a string attached to one corner by which it may later be withdrawn. Then scatter over the surface of the upper funnel two level measuring spoonfuls[3] of New Improved Ceresan. Carefully place one bushel of seed in the upper funnel in such a way as not to disturb the cloth stopper. Over this bushel of seed scatter one level spoonful of the dust. Then add another bushel of seed and another level measuring spoonful of dust. By means of the string pull out the rag stopper. **Maintain** the supply of seed in the upper funnel by adding seed. **Over each bushel of seed scatter one level spoonful of the dust.** The treated cereal seed should stand in a pile for at least 24 hours and 48 hours are preferred. Sorghum seed, however, should be planted at the end of 24 hours.

An oil drum gravity seed treater for use with New Improved Ceresan is illustrated in figure 16. When using this treater, it is recommended that 10 or 15 bushels of seed and the correct amount of New Improved Ceresan be mixed on the floor. This mixture should then be scooped into the treater. **Unless this is done the seed and chemical dust may not be properly mixed.** Before using the gravity seed treater, read carefully the directions on the New Improved Ceresan label. In using this type of treater there will be much more dust in the air than in the case of the rotary

3. A measuring spoon is supplied by the manufacturer and will be found in each container.

type machines. **Precautions as to masks and ventilation should be followed.** Treated seed should stand in a pile at least 24 hours and 48 hours are preferred, except in the case of sorghum seed. (See page 36.)

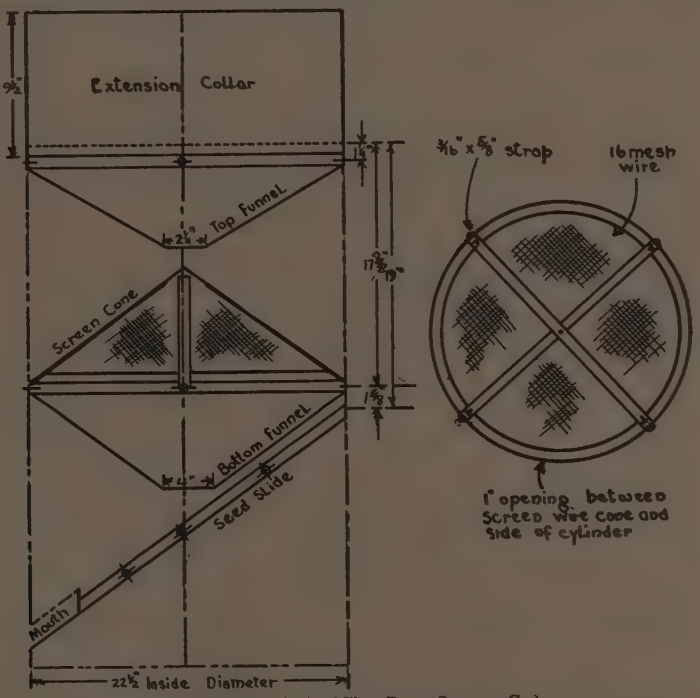


(Designed by U. S. D. A., University of Illinois, and modified by Kansas State College.)

FIG. 15.—Seed treaters specially constructed for use with New Improved Ceresan. This equipment cannot be used with copper carbonate dust.

With the use of New Improved Ceresan, a need has arisen for seed-treating equipment with a large treating capacity per hour to mix the proper amounts of seed and chemical dust. There is a growing tendency on the part of seedmen, grain dealers, elevator and

mill operators, and other central agencies to engage in treating seed grain. Likewise certain farmers who produce large acreages of cereals need equipment that will treat seed rapidly and efficiently. With this in mind, the Bureaus of Agricultural Engineering and Plant Industry of the U. S. Department of Agriculture have designed an automatic seed and dust feeding machine and also a mechanical dust feeding device for seed-treating outfits. This equip-



(Designed by G. F. Miles, Bayer-Semesan Co.)

FIG. 16.—Oil barrel gravity seed treater, to be used in applying New Improved Ceresan **only**.

ment has not yet been tried out by the Kansas Agricultural Experiment Station. Those interested may secure copies of blue prints by writing to the U. S. Department of Agriculture, Bureau of Agricultural Engineering, Washington, D. C.

Those interested in securing information on "powder feeds" and other seed-treating equipment for treating large quantities of seed with New Improved Ceresan, may write to the Department of Botany, Agricultural Experiment Station, Manhattan, Kansas, for the most recent information.

In using New Improved Ceresan, it is very essential that the exact quantities of chemical dust and seed are mixed together. Too much dust or too little will result in seed injury or the lack of smut control. The directions of the manufacturers must be explicitly followed; guesswork will result in disappointment.

For any other details regarding equipment or the chemical dust to use, see the county agricultural agent. These chemical dusts may be purchased from drugstores, hardware or implement dealers, and seed stores in most communities.

Precautions. Some of the chemical dust treatments, notably the copper carbonate dusts and New Improved Ceresan, cause nausea and irritation to the eyes, nose, and throat of the operators. The treatments should be conducted in the open air and not in a closed room. The operators should avoid breathing the chemical dust. **It is best to wear a dust mask or place a dry cloth (never wet) over the nose and mouth.** This will prevent the irritation.

Do not allow New Improved Ceresan to accumulate on the skin; wash exposed portions of the body with soap and water.

Copper carbonate sometimes cakes in the drill and causes breaking of parts. This treatment has been so generally used, however, that farmers have learned what precautions are necessary to avoid damage to the drill.

It is not advisable to feed wheat, oats, barley, or sorghum seed that has been treated with copper carbonate, New Improved Ceresan, or any of the so-called "chemical dusts." The chemical dusts used generally are poisonous; therefore, **treated seed should not be fed to livestock, chickens, or human beings.** Follow the same practice that is used in mixing concrete—don't prepare more than is necessary for the job. Treated seed cannot be washed free of the chemical dusts to a degree where it is safe or practical for feeding purposes; therefore, treat only such quantities of seed as are necessary for planting.

Formaldehyde Seed Treatments

Formaldehyde ("formalin" is the commercial term for a 37 to 40 percent solution) is a gas dissolved in water, which has a strong, penetrating odor and biting taste. It may be bought from any wholesale drug company, chemical supply store, or drugstore. In buying formaldehyde one should be certain that it is guaranteed full strength (generally said to be 40 percent). It is best to buy formaldehyde in sealed containers.

Solutions may be used several times for treating seed, but if they have been exposed to the air for longer than 48 hours they should not be used.

The formaldehyde seed treatment was first used as a preventive for oat smut, but it may be used to prevent the kernel smut of sorghums, the covered smut of barley, and the smut of millet. It was

formerly used for the prevention of stinking smut of wheat, but in recent years it has been replaced by the more practicable dust treatments. Since the introduction of the dust treatments, the formaldehyde method has been used very little. For the convenience of those who may wish to use the formaldehyde treatment, the following methods are described.

The apparatus necessary for the formaldehyde seed treatment for the various smuts just mentioned is very similar. The chief difference is in the strength of the formaldehyde solution and the length of time that the seed remains therein. The formaldehyde treatment will not materially injure the vitality of good seed, if the treatment is carefully performed according to directions. However, when seed is weakened, scratched, cracked, or broken, injury does occur, and this is one of the objections to the formaldehyde treatment. Access to water is frequently a limiting factor.

The formaldehyde treatment may be given in any one of three different ways, depending upon which of the cereal smuts is concerned. These are: (1) the dipping method, (2) the sprinkling method, and (3) the dry or mist method.

The Dipping Method.—Where this method is followed, it is necessary to use seed that has been thoroughly cleaned in a fanning mill. The solution is made by mixing the stipulated amounts of formaldehyde and water in a suitable tank, vat, or barrel. The seed to be treated is placed in coarse sacks, plunged into the solution, moved up and down until it is certain that all the grain has been thoroughly wet. The sacks are then allowed to stand in the solution from 30 minutes to 2 hours, depending upon the kind of seed. Allow more than sufficient room in the sacks for the swelling of the seed. Millet, barley, and sorghum seed may be treated by this method.

At the end of the stated time, the sacks with their contents should be removed and drained. The seed should be spread out in thin layers on a clean floor or canvas, free from smut contamination, and allowed to dry. The seed may be sown immediately after drying, or it may be stored for not longer than two or three weeks for the best results.

Sprinkling Method.—Where large quantities of oats are to be treated, the sprinkling method is much quicker and more easily performed. This method is not recommended for any of the other smuts. The grain should be spread out in a layer from 4 to 6 inches deep, and the solution, made by mixing the stipulated amounts of formaldehyde and water, applied by means of a sprinkling can. One man should sprinkle the seed very lightly while another shovels it over, as in mixing concrete. The seed should then be placed in piles and covered with clean sacking, blankets or canvas, and allowed to stand 5 hours, or overnight, after which it should be spread out and thoroughly dried.

General Precautions.—In order to eliminate all possibilities of contamination, sacks which have been used previously should be soaked for a period of two hours in the solution employed for treat-

ing the seed for smut. It is advisable to sprinkle the floor with a solution of formaldehyde before spreading the seed to dry. Bins and drills should be sterilized by washing them with a solution of formaldehyde.

The germination of treated seed should be tested, and if the germination is low, the rate of planting should be proportionately increased. Precautions should be taken against freezing or sprouting after the treatments. The seed should not be stored over three weeks.

Spray formaldehyde method.—One of the common methods for treating seed oats is the formaldehyde spray treatment. (Fig. 17.)

FIG. 17.—The formaldehyde spray method for treating seed oats.

The spray method can be used only for oat smut control. This consists of mixing 1 pint of full-strength formaldehyde with 1 pint of water. This is placed in a quart hand sprayer as ordinarily used to spray flies. The quart of mixture is sufficient to treat 50 bushels of oat seed. Two men are required to carry out this treatment. The oat seed to be treated is arranged in a large pile. Spray the solution on the grain as it is being shoveled from one pile to another, holding the sprayer close to the seed. One stroke of the sprayer gives enough mist for each shovelful of seed. If scoop shovels are used, more spray should be given. In case some solution remains after the pile has been treated, apply the remainder to the surface of the pile before covering. After the seed is treated, it should be shoveled into a pile and covered with clean sacks, blankets, or canvas for 5 hours or overnight. It is then ready for sowing. In case it is not to be used immediately, it becomes necessary to spread out and air the seed for several days before storing. **Seed treated by this method is easily injured if it is kept stored for longer than three weeks.**

Modified Hot-water Seed Treatment

Although this method has been used to some extent, it has objectionable features which make it impracticable.

The modified hot-water seed treatment is designed for the loose smuts of wheat and barley. The equipment needed consists of 3 barrels or vats filled with water and a well-regulated supply of heat to raise the temperature of the water to the proper degree. These containers are spoken of as the soaking, tempering and treating vats or baths. The essential features of the modified hot water treatment consist in soaking the seed from 4 to 6 hours in water. (The seed should be in sacks.) This is followed by immersion in hot water at 120° F. (tempering bath) for a few minutes in order to raise the temperature of the sacks and contents before they are placed in the treating bath. If barley seed is being treated, the treatment bath should be carefully regulated at 126° F. and the seed allowed to remain 13 minutes, after which the seed must be spread quickly in thin layers on a clean floor or canvas. If seed wheat is being treated, follow the same procedure except that the treatment bath temperature is 129° F. for 10 minutes.

Where steam is available, as at a creamery, it is easy to heat tanks, vats, or barrels of water to the desired temperature. The larger the volume of water, the easier it becomes to regulate the temperature of the treating bath and to prevent fluctuations. It is very important to use reliable dairy or floating thermometers and to keep the specified degree of temperature.

The Necessity of a Seed Plot

One of the most important features in connection with loose-smut control of wheat and barley is the maintenance of a seed plot. Where wheat or barley is grown on large acreages, it is impossible to treat with the modified hot-water treatment all the seed required for general planting. If a treated seed plot is maintained on a farm, it will greatly aid the farmer in overcoming the loose-smut ravages.

In starting such a plot the seed should first be carefully selected, cleaned by means of fanning, and given the modified hot-water treatment. This method requires the treatment of only a few bushels of seed, and the seed is used as a start in the production of seed free of loose smut by planting in a plot by itself. The increase from this may be used for the general crop, maintaining a small amount for the seed plot.

The selection of a location for the plot is a very important matter. **The seed plot must not adjoin a field planted to the same crop, as infection will result at flowering time.** (Page 9.) It should be located on a piece of land which is large enough to produce twice as much seed as will be required for planting the following year. This will allow for loss in cleaning. The seed plot should be maintained every year. Enough seed should be retained to plant the seed plot the following year, treating the seed regularly until the plot is clean. After this the treatment may be omitted as

long as the seed plot is free from smut. Not only can the loose smuts be eradicated from the farm in this way, but an opportunity is also afforded for growing an extra good strain of seed.

Seed Treatment for the Kernel Smut of Sorghum

Dust Treatment.—Copper carbonate, 3 oz. of the dust to each bushel of seed. New Improved Ceresan, one-half ounce of the dust to each bushel of seed, allowing the seed to stand in **an uncovered** pile for 24 hours. **Do not use more than one-half ounce, as seed injury will result.**

Use copper carbonate or New Improved Ceresan according to the directions given on the container of the product used. Care should be taken to mix the seed and dust thoroughly. This is best accomplished by using a seed-dusting outfit. (See figs. 12-16.)

Formaldehyde Treatment.—The dipping method is commonly used. The solution requires 1 pint of formaldehyde to 30 gallons of water. The process and equipment necessary are described on page 33. The formaldehyde treatment will not materially injure the vitality of good seed if the treatment is carefully performed according to directions. Seed which is cracked or otherwise mechanically injured in threshing is liable to be injured during treatment. Varieties which do not retain the glumes on the seed are more susceptible to injury. Allow the sacked seed to soak in the solution for one half hour.

Seed Treatment for Stinking Smut of Wheat

Dust Treatment.—Copper carbonate, 3 oz. of dust for each bushel of seed. New Improved Ceresan, one-half ounce of the dust for each bushel of seed, allowing the seed to stand in a pile for at least 24 hours, and preferably 48 hours.

Use copper carbonate, New Improved Ceresan, or other satisfactory chemical dusts according to directions furnished by the manufacturer. A seed-treating machine must be used if satisfactory results are to be obtained. (See figs. 12-16.)

Seed Treatment for Loose Smut of Wheat

Use the modified hot-water treatment in connection with seed plot. (Page 35.)

Control for Flag Smut of Wheat

Dust Treatment.—Use New Improved Ceresan or copper carbonate, the same as for stinking smut of wheat.

Note: While seed treatment in itself will not completely control flag smut, it is advisable to plant only treated seed in areas where flag smut occurs. This will insure killing all smut spores on the seed. If such seed is planted on smut-free land, a clean crop should result.

Seed Treatment for Smut of Oats

Dust Treatment.—New Improved Ceresan, one-half ounce of the dust for each bushel of seed. Allow the seed to stand in a pile for at least 24 hours, and preferably 48 hours.

Use New Improved Ceresan or other satisfactory brands of chemical dusts according to directions given by the manufacturer of the product. A dust treater of satisfactory make should be used. (See figs. 12-16.)

Formaldehyde Treatment.—One of two methods may be used. In the sprinkling method use 1 pint of formaldehyde to 10 gallons of water. Cover the seed with canvas, and allow to stand 5 hours or over night, after which it should be spread out to dry. (Page 33.) In the spray method use 1 pint of formaldehyde to 1 pint of water. Apply mist and cover 5 hours or over night. (Page 34.)

Seed Treatment for Covered Smut of Barley

Dust Treatment.—New Improved Ceresan, one-half ounce of the dust for each bushel of seed. Allow the seed to stand in a pile for at least 24 hours, and preferably 48 hours.

The only satisfactory dust treatment found so far for the covered smut of barley is New Improved Ceresan. This dust will also control the barley stripe disease, which is becoming more prevalent in Kansas. A dust treating machine should be used and precautions taken to see that the seed is covered with the chemical dust. The directions of the manufacturer should be followed for the use of the dust.

Formaldehyde Treatment.—Use the dipping method. The solution requires 1 pint of formaldehyde to 40 gallons of water. (Page 33.) Soak cleaned seed in formaldehyde solution for 2 hours. Remove, drain, and dry seed.

Seed Treatment for Loose Smut of Barley

Use the modified hot-water treatment in connection with seed plot. (Page 35.)

Seed Treatment for Smut of Millet

Dust Treatment.—Copper carbonate dust at the rate of four ounces, or New Improved Ceresan one half ounce, to the bushel of seed will give complete control. Care should be taken to mix thoroughly the seed and dust. The directions of the manufacturer should be followed for the use of the dust. When using New Improved Ceresan, allow the seed to stand in a pile for at least 24 hours, and preferably 48 hours.

Formaldehyde Treatment.—Use 1 pint of formaldehyde to 45 gallons of water. The process and equipment necessary for the dipping method have been described on page 33. The seed should remain in the solution 2 hours, after which it should be spread out and dried.